Tree Species Diversification Decision Support Tool

Introduction

This decision support tool has been developed to provide additional guidance to decision makers while choosing tree species for their management plans. It also shows the risk reduction benefits of diversifying species in the presence of risks.

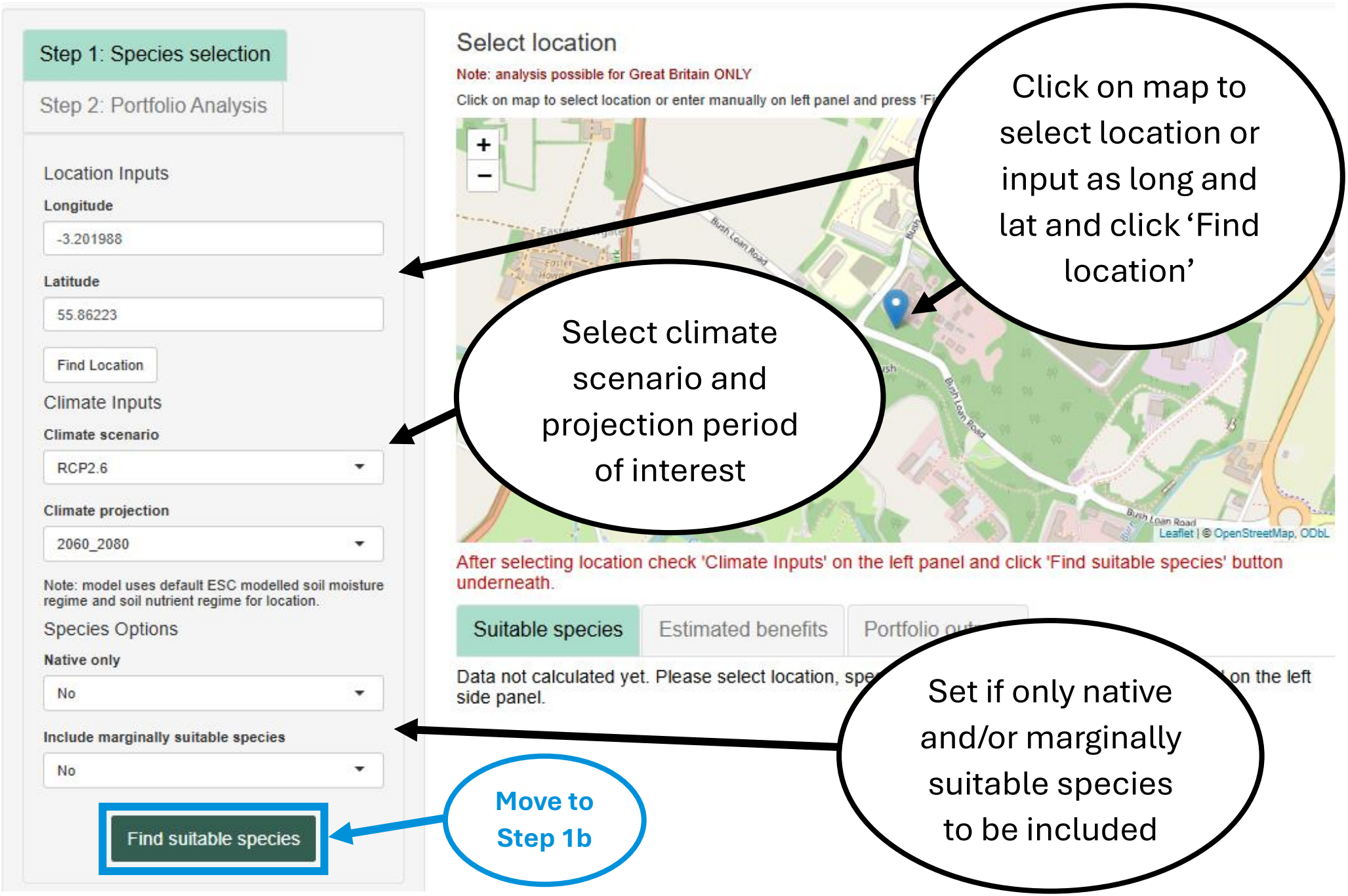
The tool estimates the expected benefits of each tree species at a given location and includes the impact of possible wind damage and pest & disease outbreaks. Portfolio analysis is used to find the mix of species that provides the lowest risk for each level of benefit. The tool allows the user to mix weightings of different benefits (timber, carbon, biodiversity, and health & wellbeing) and management types (timber focused and recreation focused).

This tool is designed to start conversations about some of the risks faced by future treescapes and the potential benefits of diversification. It is not designed to provide a single solution but rather to create various scenarios for stakeholders to discuss. It is important to keep in mind that the tool has limitations due to gaps in current scientific knowledge and data.

Step 1a: Find suitable species for site

Enter the initial details. For location specific species suitability and expected stand growth Forest Research's (FR) Ecological Site Classification (ESC) tool is used.

1. The location of the site can either be entered by clicking on the map or as coordinates. No default location is provided. To set the location by clicking on the map, zoom to the location of interest or alternatively use the search bar in the top right of the map and left-click on the specific location. The longitude and latitude will automatically update to reflect the selected location. Alternatively, entering the longitude and latitude as numbers will update the pin location after "Find location" is clicked. Check the pin to ensure the correct location is chosen.
2. Enter which climate projections you wish to use for the species suitability and growth models to be based on. By default, the Representative Concentration Pathways (RCPs) RCP2.6 pathway climate scenario is used, characterised by an average 1.6°C temperature change by 2081-2100 (further information on all RCPs can be found here). The default projection years used are 2060-2080.
3. Specify if only native species are to be included. By default, all species (native and non-native) are included. Nativeness is defined as species that colonised Great Britain naturally in the post-glacial period.
4. Specify whether to include species that are marginally suitable. By default, marginally suitable species are not included in the subsequent analysis. Marginally suitable species are those that while suitable have a higher risk of reduced or halted growth, or even complete failure.

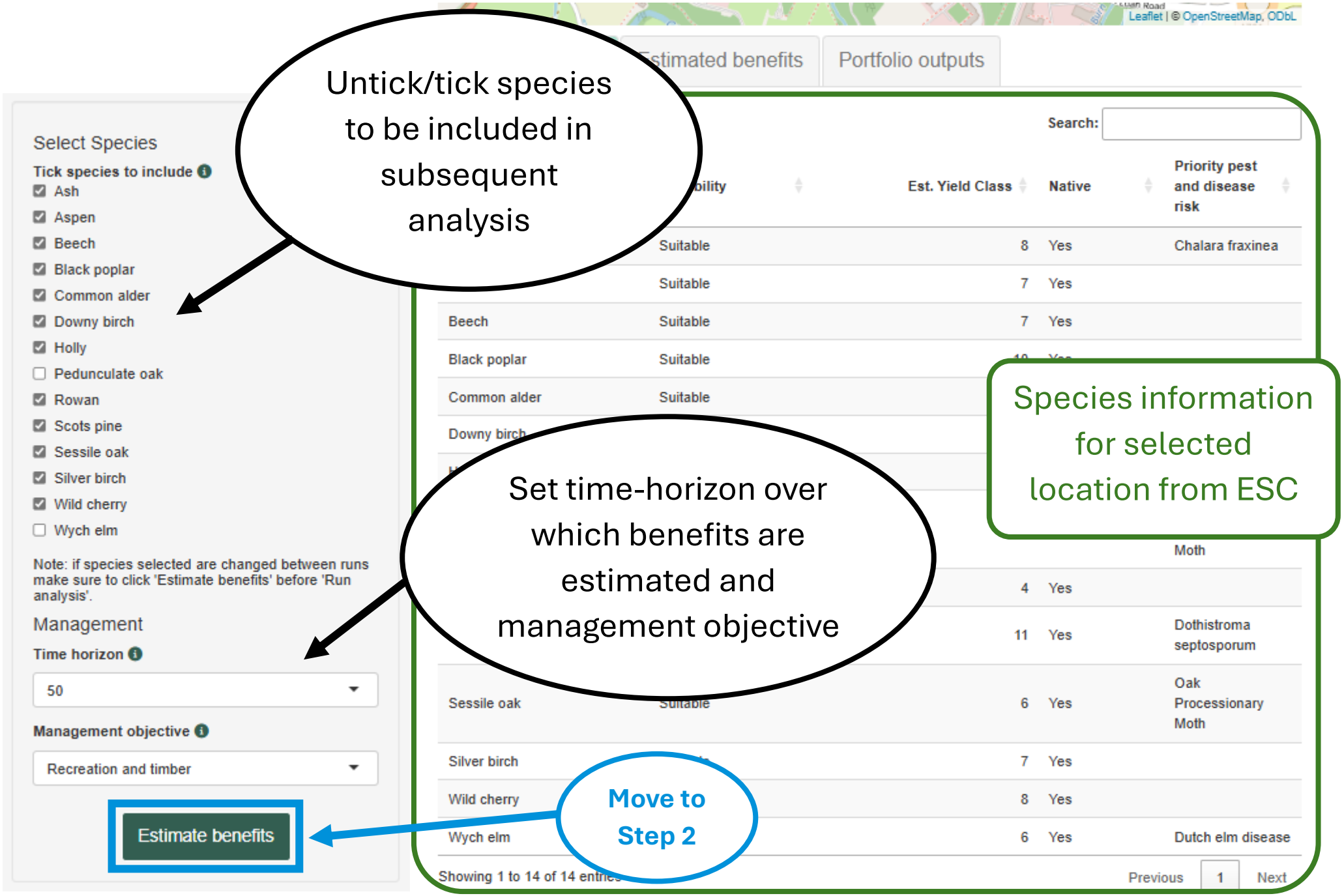

Step 1: Species selection
Step 2: Portfolio Analysis
Location Inputs
Longitude
-3.201988
Latitude
55.86223
Find Location
Climate Inputs
Climate scenario
RCP2.6
Climate projection
2060_2080
Note: model uses default ESC modelled soil moisture regime and soil nutrient regime for location.
Species Options
Native only
No
Include marginally suitable species
No
Find suitable species
Select location
Note: analysis possible for Great Britain ONLY
Click on map to select location or enter manually on left panel and press 'Fi
Bush Loan Road
Leaflet | © OpenStreetMap, ODbL
After selecting location check 'Climate Inputs' on the left panel and click 'Find suitable species' button underneath.
Suitable species
Estimated benefits
Data not calculated yet. Please select location, spe
on the left side panel.
Click on map to select location or input as long and lat and click 'Find location'
Select climate scenario and projection period of interest
Set if only native and/or marginally suitable species to be included
Move to Step 1b

Step 1b: Species benefit estimation

Species selection and management objective. On the main panel an overview of the predicted suitability and growth rate (yield class) of each species at the location are given. Nativeness and any notable pest & diseases of concern are also shown to the user.

1. A full list of tree species suitable for the site is given based on previous inputs. The user has the option to select those they wish to include in subsequent analysis by clicking the tick-boxes next to each species. By default, the 12 most suitable species according to ESC are included.
2. The user selects the time horizon over which to estimate benefits. By default, a 50-year time horizon is used, with an option of 100-year also available. A 50-year time horizon broadly aligns with a typical conifer rotation whereas a 100-year time horizon suit longer-term projects or where timber from slower-growing hardwoods is included.

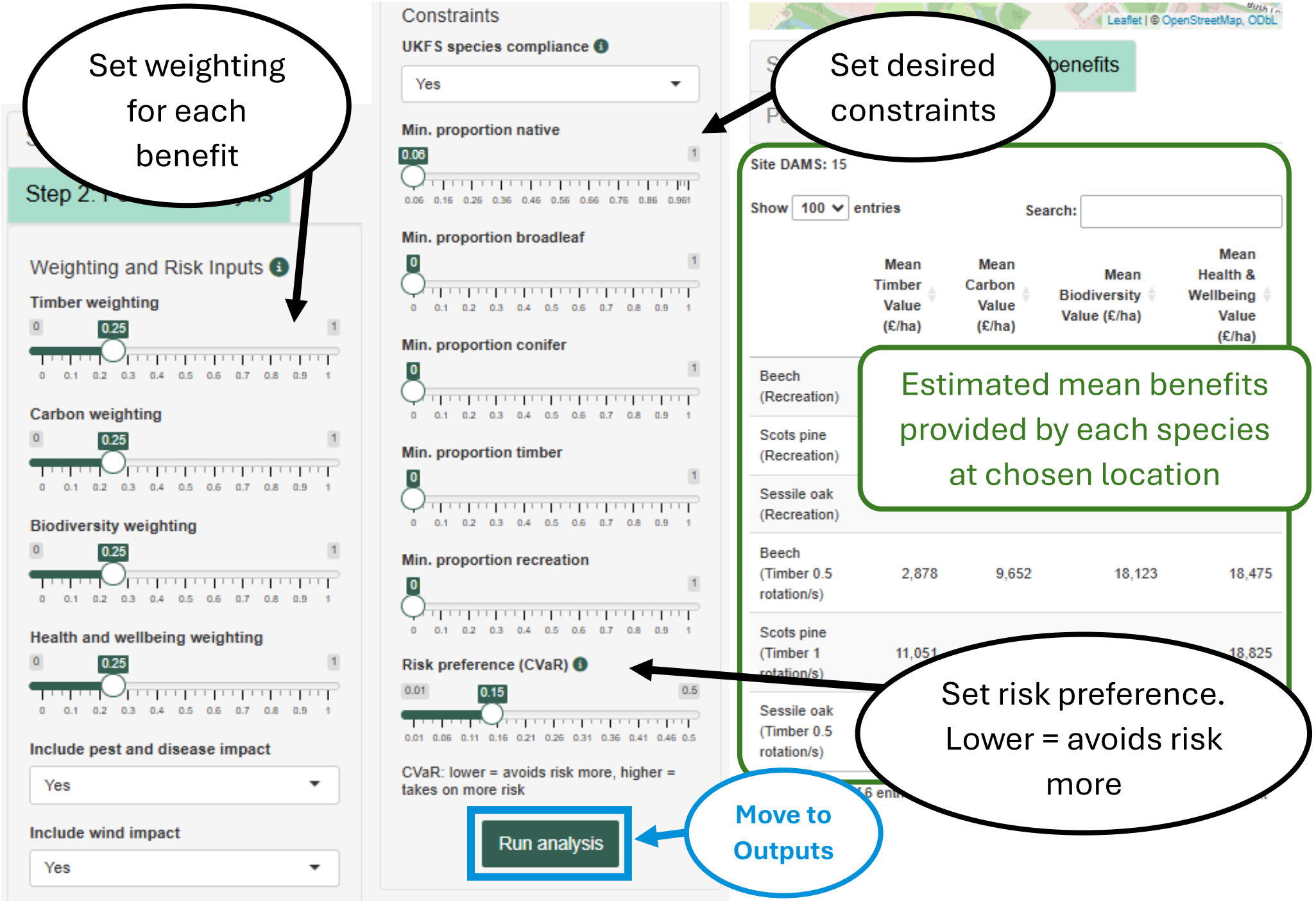
Note: For estimating benefits and risk events the Monte-Carlo simulation is run 10,000 times. This aligns with standard statistical practices. The number of runs determines the precision of results, with a higher number of simulations seeing less variance in results.


Leaflet | © OpenStreetMap, ODbL
Estimated benefits
Portfolio outputs
Search:
Select Species
Tick species to include
Ash
Aspen
Beech
Black poplar
Common alder
Downy birch
Holly
Pedunculate oak
Rowan
Scots pine
Sessile oak
Silver birch
Wild cherry
Wych elm
Note: if species selected are changed between runs make sure to click 'Estimate benefits' before 'Run analysis'.
Management
Time horizon
50
Management objective
Recreation and timber
Estimate benefits
Untick/tick species to be included in subsequent analysis
Set time-horizon over which benefits are estimated and management objective
Species information for selected location from ESC
Move to Step 2
Est. Yield Class
Native
Priority pest and disease risk
Beech Suitable 7 Yes
Black poplar Suitable
Common alder Suitable
Downy birch
Moth
4 Yes
11 Yes Dothistroma septosporum
Sessile oak 6 Yes Oak Processionary Moth
Silver birch 7 Yes
Wild cherry 8 Yes
Wych elm 6 Yes Dutch elm disease
Showing 1 to 14 of 14 entries
Previous
1
Next

Step 2: Portfolio analysis

Select weightings for different benefits, set which risks to include, and add any additional constraints. The estimated mean value of each type of benefit (before wind and pest & disease impacts) is presented to the user in the main panel.

1. Set the weightings used for each type of benefit. By default, an equal weighting is used for each. If chosen weightings do not add up to 1 these will automatically be adjusted so they do. Setting a benefit weighting to 0 effectively removes it from the portfolio analysis. If the 'Recreation' management objective is chosen then the "Timber weighting" option is set to zero as the woodland is not felled.
2. Choose whether to include pest & disease impact. By default, pest & disease impacts are included.
3. Choose whether to include wind impacts. By default, wind impacts are included.
4. Set constraints. By default, UK Forestry Standard (UKFS) constraints are used requiring a minimum of ~6% area for native species and a maximum of ~72% area for any one species of the planted area (10% open ground in the project area would also be required). This can be removed by selecting "No" in "UKFS species compliance", meaning no constraints are set. The user then has the option of choosing minimum proportions of native, broadleaf, and conifer species. If management objective "Recreation and timber" is chosen, there is also the option to choose a minimum proportion of woodland managed for timber or for recreation.
5. Set risk preference. By default, this is set at 0.15 meaning that the model finds the optimal species mixes by maximising expected benefits whilst minimising the average loss in benefits in the worst 15% of cases. This can be set between 0.01 (more risk-averse, minimising losses in the worst 1% of cases) and 0.5 (less risk averse, minimising the loss in the worst 50% of cases).


Set weighting for each benefit
Weighting and Risk Inputs
Timber weighting
Carbon weighting
Biodiversity weighting
Health and wellbeing weighting
Include pest and disease impact
Yes
Include wind impact
Yes
Constraints
UKFS species compliance
Yes
Min. proportion native
Min. proportion broadleaf
Min. proportion conifer
Min. proportion timber
Min. proportion recreation
Risk preference (CVaR)
CVaR: lower = avoids risk more, higher = takes on more risk
Run analysis
Move to Outputs
Set desired constraints
Leaflet | © OpenStreetMap, ODbL
benefits
Site DAMS: 15
Show 100 entries
Search:
Mean Timber Value (£/ha)
Mean Carbon Value (£/ha)
Mean Biodiversity Value (£/ha)
Mean Health & Wellbeing Value (£/ha)
Beech (Recreation)
Scots pine (Recreation)
Sessile oak (Recreation)
Beech (Timber 0.5 rotation/s) 2,878 9,652 18,123 18,475
Scots pine (Timber 1 rotation/s) 11,051 18,825
Sessile oak (Timber 0.5 rotation/s)
Estimated mean benefits provided by each species at chosen location
Set risk preference. Lower = avoids risk more

Outputs and interpretation

After clicking "Run analysis" you are presented with the results of the portfolio analysis on the main panel. If objective "Recreation and timber" is chosen (Rec) and (Timb) are used to indicate the two management types for each species.

1. **Specifications used for analysis**. This shows all inputs entered previously. Check these before interpreting results to ensure these reflect your needs.
2. **Stacked bar chart of recommended portfolios**. This presents the optimal species mixes (portfolios) estimated in the model. In most cases three species mixes will be presented: the minimum risk species mix on the left, the max benefits species mix on the right, and a balanced species mix in the centre. These points directly correspond to the coloured points (green, amber, red) on the efficient frontier shown in the next chart. In cases where only one or two optimal species mixes are found these are presented in the same way. The balanced portfolio is the point on the efficient frontier between the "Min risk" and "Max benefit (Max)" where the rate of change between risk and benefit increasing is closest to one.
3. **Efficient frontier and single species risk and benefits**. The efficient frontier displays all feasible optimal species mixes (portfolios) in terms of their risk and benefits. Also shown are each individual species and the equal weights portfolio "EWP" (representing an equal proportion of each species). Points further to the left have a lower risk and points higher up have greater expected benefits. In the example shown the efficient frontier is further to the left compared to where only one species is used, showing the risk reduction benefit of mixing species.
4. **Weighted benefits with included natural impacts**. This shows the distribution of benefits for each species including the simulated impacts from wind and pest & diseases.
5. **Tree species benefits correlation plot**. Shows the correlation between the benefits of each species.

Include pest and disease impact

Yes

Include wind impact

Yes

Constraints

UKFS species compliance

Yes

Min. proportion native

0.06

Min. proportion broadleaf

Min. proportion conifer

Min. proportion timber

Min. proportion recreation

Run analysis

Leaflet | © OpenStreetMap, ODbL

Suitable species | Estimated benefits | Portfolio outputs

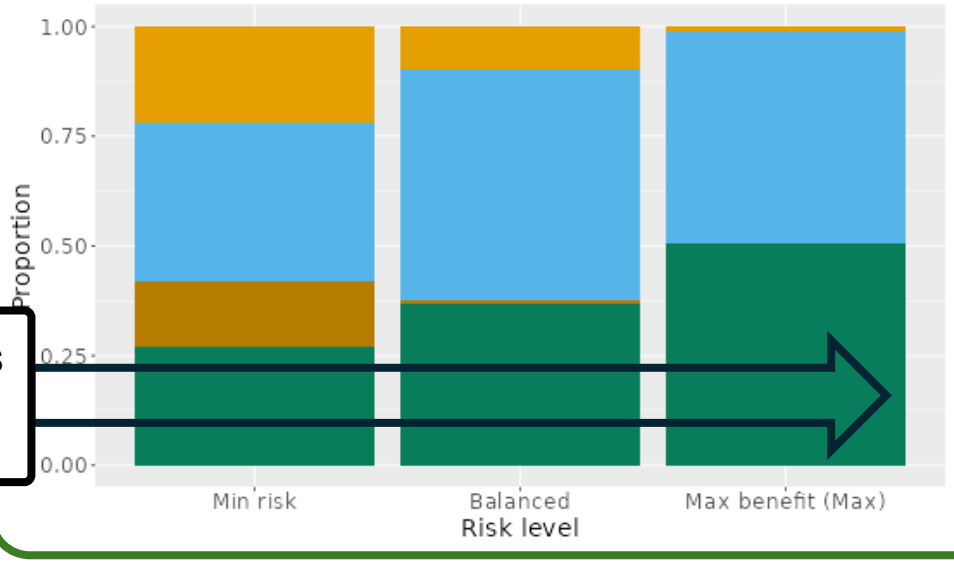
All inputs used in analysis

Specification used for analysis

Check inputs (especially any specified weightings and constraints) BEFORE interpreting analysis

Input	Specification	Input	Specification
Latitude	55.8622	Longitude	-3.202
Climate scenario	RCP2.6	Number of simulations	10,000
Climate years	2060_2080	Include pest and disease impact	Yes
Site DAMS	15	Include wind impact	Yes
Native only	Yes	UKFS species compliance	Yes
Include marginally suitable species	No	Min. proportion native	0.06
Time horizon	50	Min. proportion broadleaf	0
Management objective	Recreation and timber	Min. proportion conifer	0
Timber weighting	0.5	Min. proportion timber	0
Carbon weighting	0.25	Min. proportion recreation	0
Biodiversity weighting	0.25	CVaR Risk Value	0.15
Health and wellbeing weighting	0		

Stacked barchart of recommended species portfolios

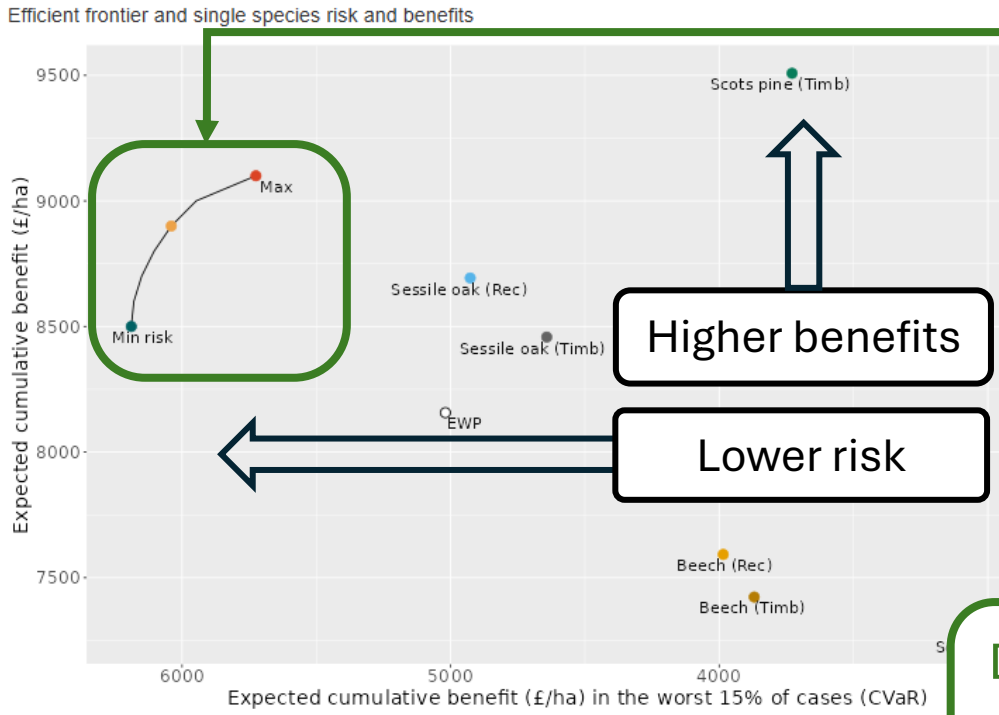


Recommended mixes of species

Higher risk & higher benefits going from left to right

Corresponds to efficient frontier (next page)

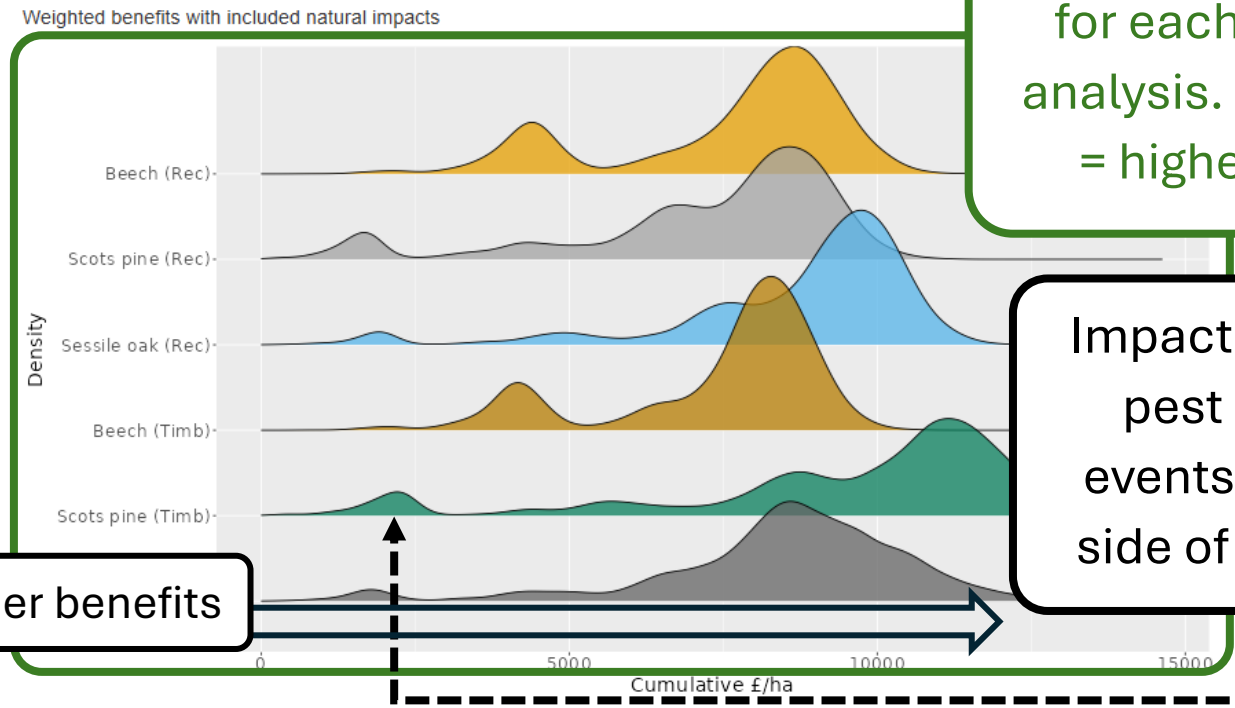
Run analysis



Higher benefits

Lower risk

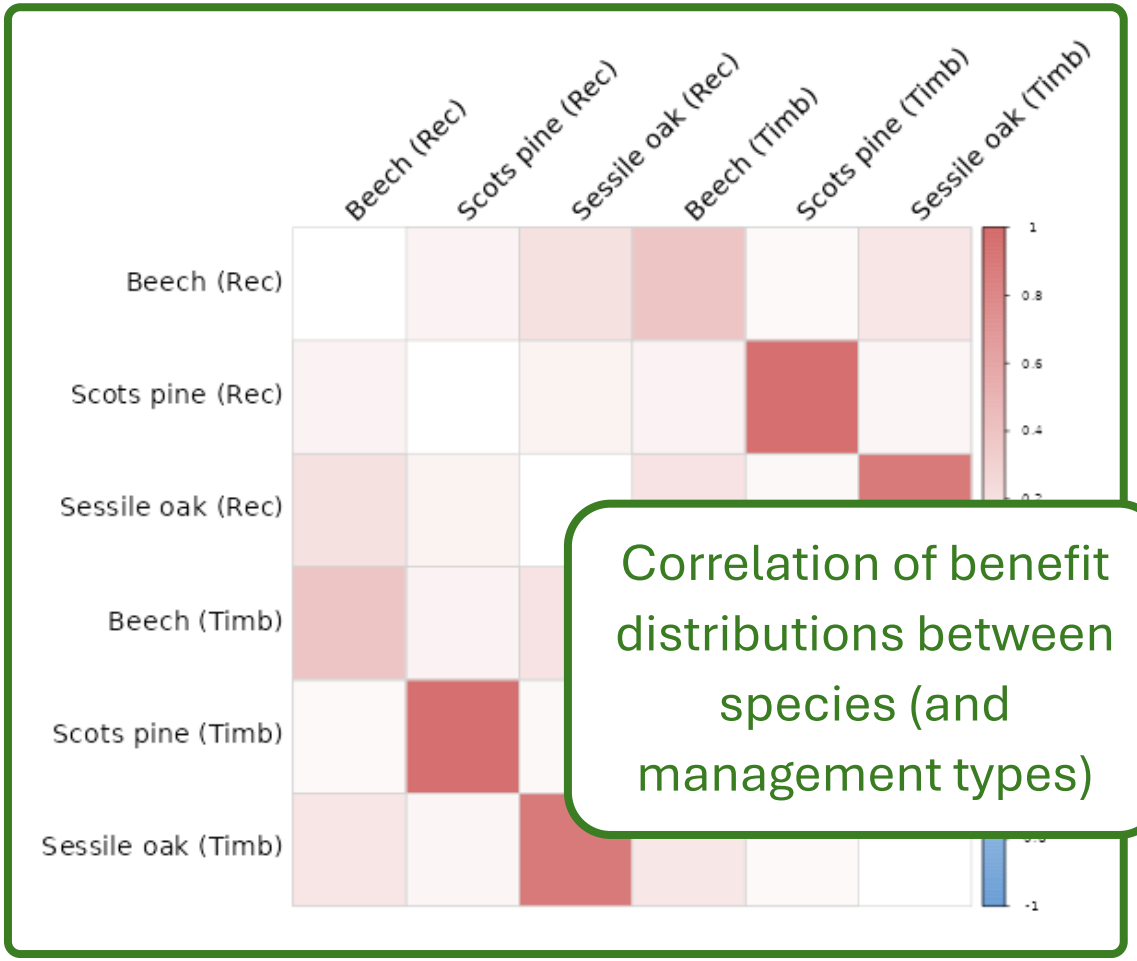
Efficient frontier: each point along here is the lowest risk possible for each level of benefit achieved through diversification



Distribution of benefits for each species in analysis. Further right = higher benefits

Impact of wind and pest & disease events seen in left side of distribution

Higher benefits



Correlation of benefit distributions between species (and management types)

Benefit estimation summary

Timber: Based on the volume of timber, the average tree size at harvest, and the expected value of timber for trees of that size. Softwood prices are based on FR's "Coniferous Standing Sales Price" (available here) and hardwood prices are based on FR's "Hardwood Price-size Curves" produced in collaboration with Grown in Britain (available here).

Carbon: Based on expected total carbon sequestration using Woodland Carbon Code Calculator lookup tables and the average carbon price based on historic price data for UK carbon units.

Biodiversity: Based on data from Alexander, Butler and Green (2006) (available here) and supplemented with expert judgement by the project team. Tree species scores were converted to monetary values by mapping the relative scores of each species to the range of values provided for woodland biodiversity in Defra's "Enabling a Natural Capital Approach" (ENCA) Services workbook (available here). Monetary value is assumed to increase linearly from 0 to 20 years after planting, with a further increase in value assumed for non-timber native broadleaves.

Health & wellbeing: Scores were given based on the estimated pollution absorption ability of each tree species and management type using the DO3SE-Tree Tool produced by the University of York. Expert judgement was used to map species to proxy species where these were not available in the model. Tree species scores were converted to monetary values by mapping the relative scores of each species to the range of values provided for woodland pollution removal in Defra's ENCA Services workbook (available here). Monetary value is assumed to increase linearly from 0 to 20 years after planting.

Risk simulation

Pest & disease risk: Uses data from the UK Plant Health Risk Register (available here) to estimate tree species specific impacts. Each pest & disease has a record of potential hosts, and scores for the likelihood of occurrence and expected impact if a host is affected. These scores are used to estimate the probability of a pest & disease event happening and the impact of that event if it does occur.

Wind risk: Uses FR's ForestGALES software combined with the windiness score (DAMS) for the chosen location to estimate tree species specific risk. The probability of damage is estimated over the time horizon chosen. For each wind damage event that occurs benefits are reduced by 50% in that run of the Monte-Carlo simulation.

Reductions in benefits compound when multiple events occur. E.g., two 50% reduction events would lead to a 75% reduction in benefits.